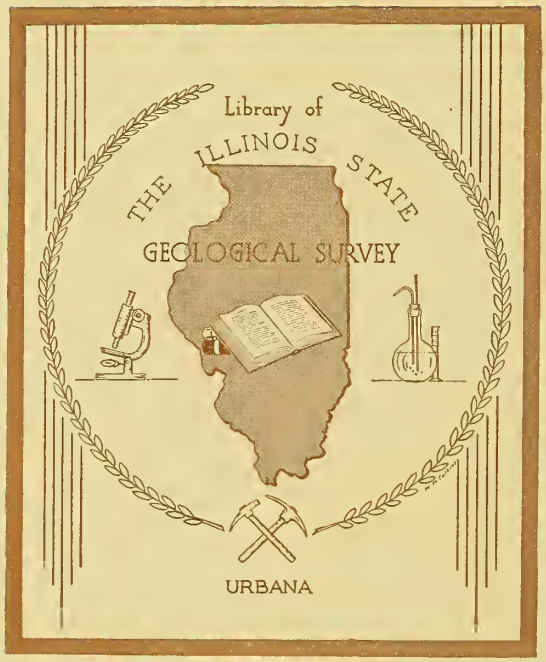

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ENVIRONMENTAL GEOLOGY NOTES

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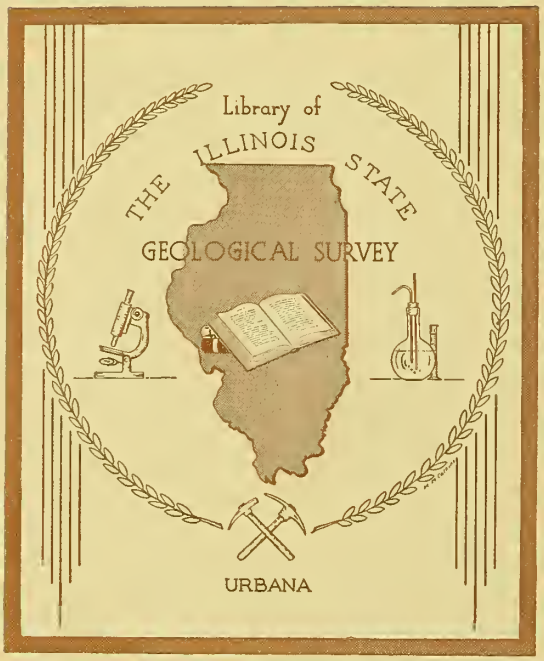
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URBAN EXPANSION—AN OPPORTUNITY AND A CHALLENGE TO INDUSTRIAL MINERAL PRODUCERS

H. E. Risser and R. L. Major

In recent years, the industrial minerals industry has been faced with the greatest opportunities and the greatest challenges in its history. The opportunities stem primarily from the increased demand resulting from a rapidly growing population and from an even more rapid growth in per capita consumption of mineral products. Urbanization leads to a greater concentration of population, which provides larger, more concentrated market outlets. These, in turn, bring the opportunity for larger, more efficient operating units.

At the same time, urbanization results in numerous problems and challenges for the urban mineral producer. Some of the existing pits and quarries have been rendered uneconomic to operate because of various operational restrictions imposed by local governments. Many of the potential mineral reserves in and near the urban centers are being built over by "urban sprawl," while others are being made unavailable by restrictive zoning ordinances. The Chicago metropolitan area provides an example of the relationship between sand, gravel, and stone deposits and urbanization.

Advance planning for multiple or sequential use of the land can help industrial minerals producers to retain their present operating rights and obtain permission to open new properties even though zoning ordinances are becoming more stringent.

INTRODUCTION

In the years since World War II, the industrial minerals industry has been faced with the greatest opportunities and the greatest challenges in its history. Furthermore, both the opportunities and the challenges promise to become even greater in the coming decades.

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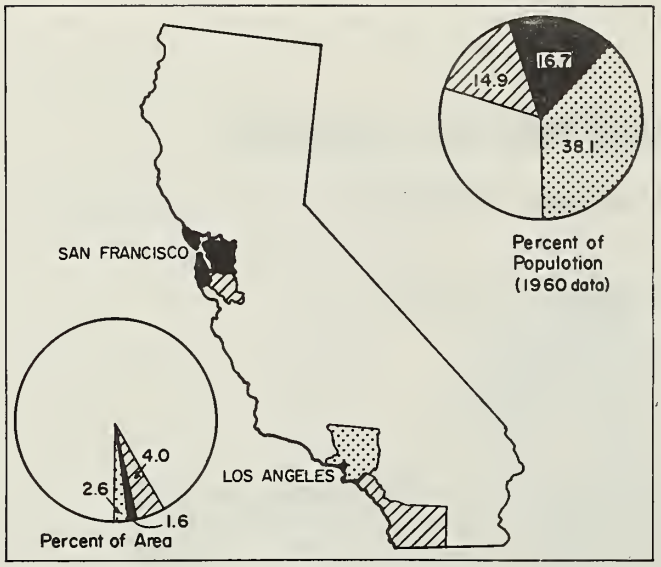


Fig. 1—Concentration of population in California.

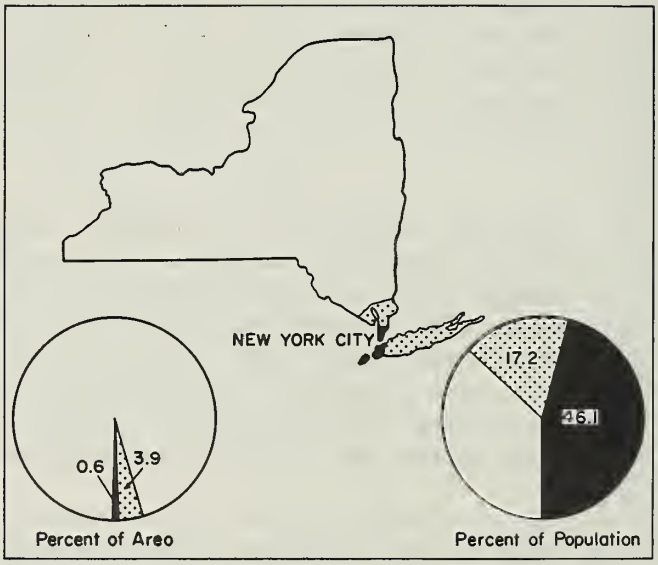


Fig. 2—Concentration of population in New York state.

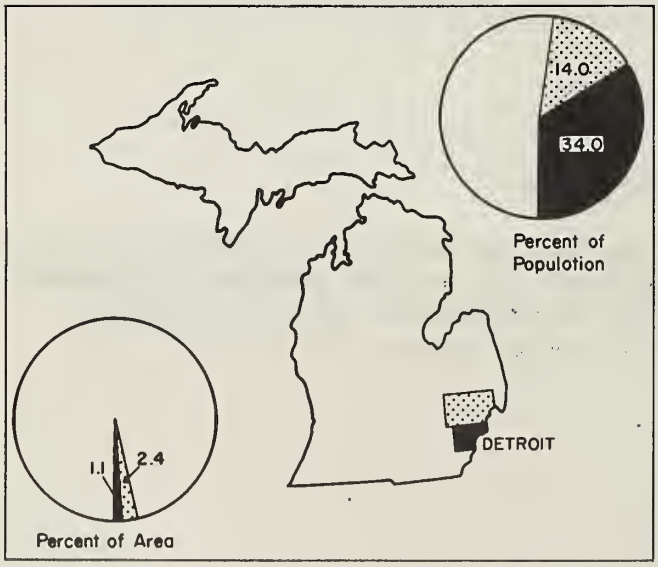


Fig. 3—Concentration of population in Michigan.

The opportunities stem primarily from the increased demand resulting from a rapidly growing population and from an even more rapid growth in per capita consumption of mineral products. Urbanization is leading to a greater concentration of population, which provides larger, more concentrated market outlets. These, in turn, bring the opportunity for bigger units, which can operate at greater efficiency and economy of scale. Delivery to such markets may also permit the use of unit trains or other large-tonnage, low-cost transportation.

While the opportunities are fairly apparent, it also is clear that numerous challenges must be met and obstacles overcome in order to take fullest advantage of these opportunities.

The challenge of greater demand will require the development of an industry composed of operating units with sufficient size, resources, and financial strength to enable it to produce on the large scale necessary to supply that demand.

New sources of raw materials will be needed to replace those that are being rapidly depleted. Some sources are being rendered uneconomic because of various operational restrictions. Many of the potential reserves are being covered as a result of urbanization or are being made unavailable by restrictive zoning ordinances.

POPULATION TRENDS

In the 25 years from 1940 to 1965, the U. S. population increased almost 50 percent, from 132 million to 194 million people. The projections for 1975 indicate a population of 214 to 227 million (U. S. Bur. Census, 1966, p. 5-6).

The population growth has not been equal for all areas, however. The total increase in the United States between 1950 and 1960 was 19 percent, but in Florida it was 78.7 percent, in California, 48.5 percent, and in Pennsylvania only 7.8 percent (U. S. Bur. Census, 1966, p. 13).

Along with increased population, there has been a notable trend towards increased urbanization. In 1910, 46 percent of the U. S. population was classified as urban. By 1960, urban population had increased to 70 percent (U. S. Bur. Census, 1966, p. 15). Today, an estimated 70 percent of the population is concentrated on about one percent of the land area (Abrams, 1965, p. 151).

Figure 1 shows that in California, which has a population of 18.6 million, 70 percent of the people live on 8 percent of the land. Los Angeles County alone, with less than 3 percent of the state's area, accounts for almost 40 percent of the population. Figure 2 shows the extreme concentration of population in the New York City area. In 1960 the five boroughs of the city, shown in black, contained 7.8 million people in an area of only 299 square miles. The metropolitan New York area (black and dotted area) constitutes only 4.5 percent of the state's area but contains more than 60 percent of the population. Figure 3 shows the relationship between the population

TEN MOST POPULOUS STATES
(1960 Data)

	Percent of United States Total
AREA (including Alaska and Hawaii)	21
POPULATION	55
TONNAGE PRODUCED, 1964:	
SAND AND GRAVEL	42
CLAYS	44
CEMENT	44*
STONE	46
GYPSUM	48
FRASCH SULFUR	53
ASBESTOS	54
FLUORSPAR	59
LIME	60*
SALT	68
PHOSPHATE ROCK	75

* Minimum figures; data is partially concealed.

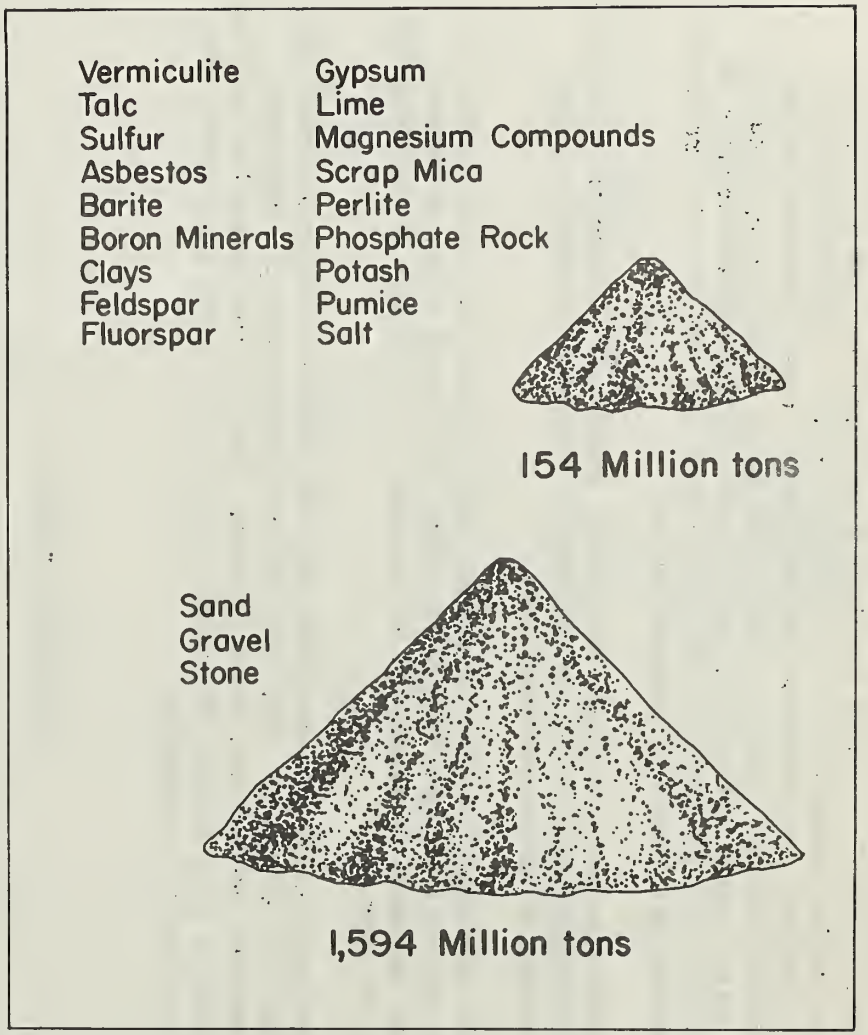


Fig. 4—(left) Area, population, and industrial mineral production of the 10 most populous states as a percentage of the U.S. total.

Fig. 5—(above) Comparison of 1964 sand, gravel, and stone production with production of other major industrial minerals (U.S. Bur. Mines, 1965b).

in the Detroit metropolitan area and that of the state of Michigan. The three-county metropolitan region makes up only 3.5 percent of the state's land area, but contains almost half of the population.

LOCATIONAL FACTORS

Production of industrial minerals, especially those used for construction purposes, tends to be concentrated in or near the urban centers. Other factors, such as geology, availability of low-cost transportation, and the ratio of unit value to unit transportation costs, modify this tendency.

Figure 4 shows the 10 most populous states and the percentage of domestic production of various major industrial minerals mined in them. These 10 states constitute only 21 percent of the land area of the United States, but they contain 55 percent of the population. As a group they consistently produce a greater share of the minerals listed than the proportion of land area they occupy, which seems to corroborate the thesis that industrial minerals production tends to be concentrated near population centers.

Low-cost, high-volume, widely occurring minerals tend to have a high "place value"; that is, the location of the deposit with respect to the point of consumption is extremely important in determining which deposits are economical and which will be utilized. On the other hand, minerals of more limited geologic occurrence and higher unit value may be profitable to mine despite their distance from market and thus have a relatively low place value. Some examples of mineral commodities with high place value are sand, gravel, crushed stone, pumice, lime, common clays, and gypsum which, in general, are produced as near the point of consumption as possible (Ladoo, 1959, p. 304-305).

MINERAL AGGREGATES INDUSTRY

Because sand, gravel, and stone are the principal industrial minerals from the standpoint of tonnage, geographic distribution, and land area involved, we will concentrate primarily on these commodities.

Figure 5 shows the tonnage production of sand, gravel, and stone compared with the total tonnage output of 18 other major industrial minerals for 1964 in the United States (U. S. Bur. Mines, 1965b, p. 3-4). Sand, gravel, and stone production was 10 times greater than the combined production of all other industrial minerals.

Despite their low unit values of $1.00 to $1.50 per ton, the total 1964 value of the United States production of sand, gravel, and stone was estimated at $2.03 billion (U. S. Bur. Mines, 1965b, p. 4). For comparison, this dollar value is equal to 44 percent of the value of production for all nonmetallic minerals, to 9.9 percent of the value of total domestic production of all minerals including fuels, and to 90 percent of the value of production for all metallic minerals produced in 1964.

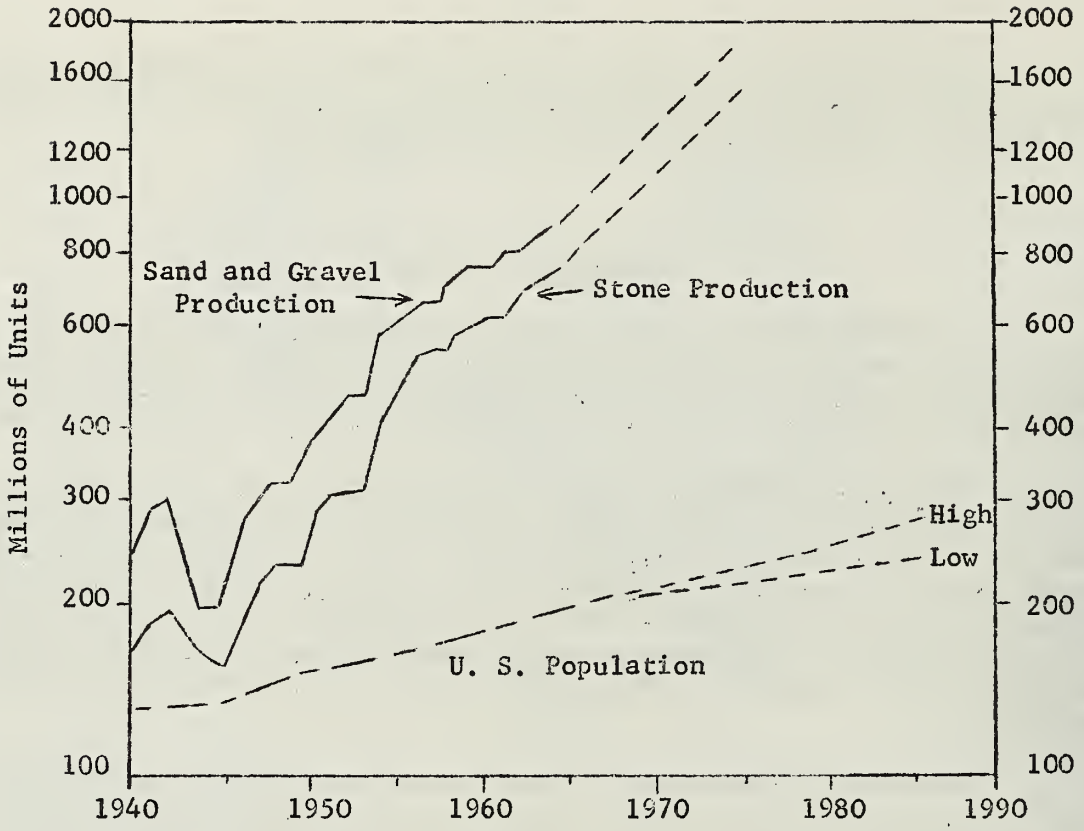


Fig. 6—Rates of growth for sand, gravel, and stone production, 1940-1975, and for total United States population, 1940-1985 (U. S. Bur. Census, 1967; U. S. Bur. Mines, 1965a).

From 1940 to 1965, cumulative stone production in the United States amounted to 10.1 billion tons. Sand and gravel production during the same period was 12.9 billion tons—enough to cover the entire state of Rhode Island to a depth of about 7 feet—while strip coal production was 2.95 billion tons, and phosphate rock production was only 317 million tons (U. S. Bur. Mines, 1941-1966).

Figure 6 compares the 1940 to 1965 growth in production of sand and gravel and stone with the growth in United States population. Projections of future growth to 1975 also are shown. The projected growth rate of sand and gravel production between 1964 and 1975 is 6.8 percent per annum and for crushed stone 6.9 percent per annum (U. S. Bur. Mines, 1965a, p. 13).

Table 1 shows the concentration of production of mineral aggregates in seven metropolitan areas. Not only do these areas account for a large percentage of their states' total production, but also the absolute amounts they produce are quite sizable. For example, in 1964 the production of sand and gravel from the Los Angeles metropolitan area was 39 million tons, an amount which exceeded the individual state production of sand and gravel in all states but New York, Michigan, and California for the same year (U. S. Bur. Mines, 1965a, p. 922-923).

TABLE 1—EXAMPLES OF EXTREME CONCENTRATION OF INDUSTRIAL MINERAL PRODUCTION IN OR ADJACENT TO URBAN AREAS IN THE UNITED STATES*

Commodity	Geographical area	Percent of state area	1964 tonnage (million)	Percent of state tonnage
Stone (Crushed & broken)	Cook County (Chicago), Ill.	1.7	12.2	31.6
Limestone (Crushed & broken)	Dade County (Miami), Fla.	3.7	10.2	32.3
Stone (All types)	St. Louis County, Mo.	0.7	5.2	16.5
Sand and gravel	Chicago Metropolitan Area (Cook, Will, Kane, DuPage, McHenry, and Lake Counties)	6.6	12.6	41.6
Sand and gravel	Los Angeles County	2.6	26.2	23.2
Sand and gravel	Los Angeles Metropolitan Area (Los Angeles, Orange, and San Diego Counties)	8.2	39.2	34.7
Sand and gravel	Detroit Metropolitan Area (Livingston, Washtenaw, Oakland, Macomb, and Wayne Counties)	5.7	18.7	36.0
Sand and gravel	Suburban Long Island (Nassau and Suffolk Counties)	2.5	10.6	27.0
Sand and gravel	Denver Metropolitan Area (Adams, Denver, Arapahoe, Boulder, and Jefferson Counties)	3.5	6.3	30.1

*Source: U. S. Bureau of Mines and U. S. Bureau of the Census

CASE HISTORY: CHICAGO METROPOLITAN AREA

The discussion to this point has dealt with the broad, nationwide picture. The Chicago metropolitan area provides a much more detailed example of these problems.

Illinois is a major industrial minerals producer; in 1964 it ranked sixth in sand and gravel production with 35 million tons, and third in total stone production with 43 million tons. Figure 7 shows the relationship

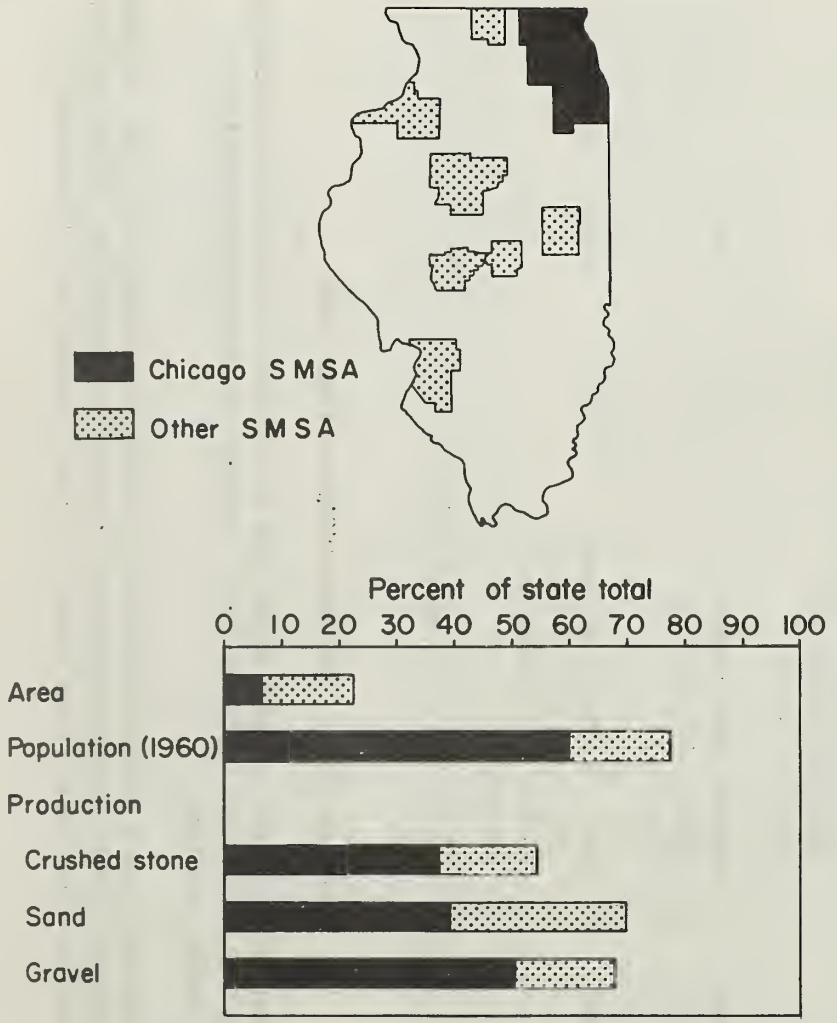


Fig. 7—Relation between land area, population, and mineral production in Standard Metropolitan Statistical Areas (SMSA) of Illinois.

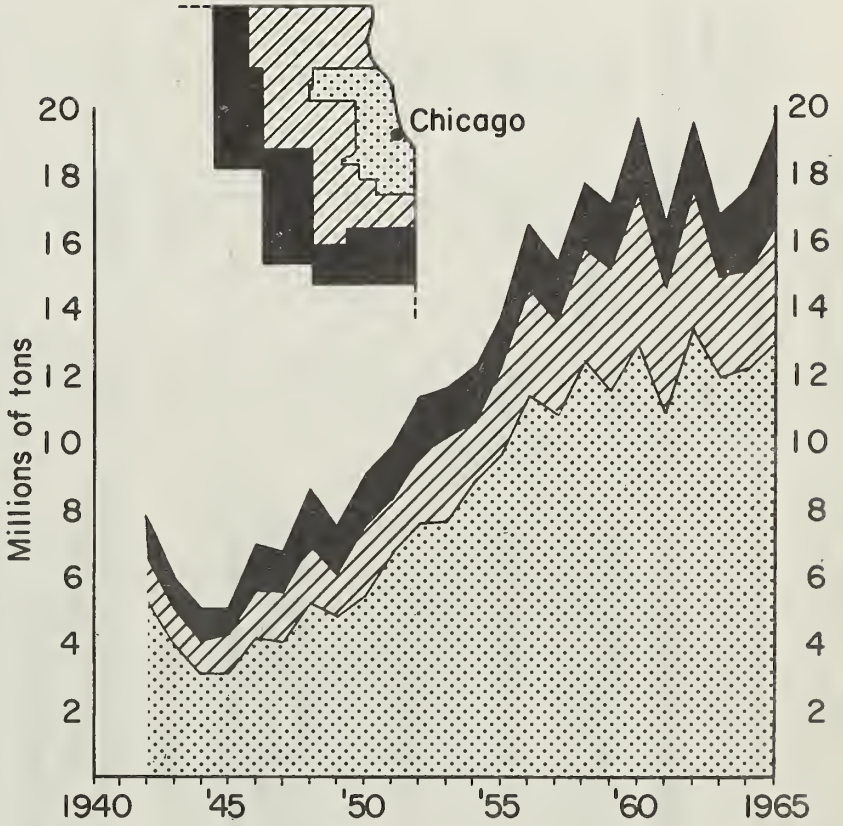


Fig. 8—Stone production in northeastern Illinois, 1942-1965. Dotted and lined patterns indicate the Chicago metropolitan area; outlying fringe area is shown in black.

between population, urban areas, and the production of sand, gravel, and stone in the state. The eight metropolitan areas shown make up only 21 percent of the state's area, but contain 78 percent of the population. The northeastern Illinois region (Chicago metropolitan area), shown in black, occupies only 7 percent of the area but contains 62 percent of the population. In 1964 this region produced 38 percent of the stone, 39 percent of the sand, and 51 percent of the gravel for the state.

The six counties of the area — Cook, DuPage, Lake, Kane, McHenry and Will — cover 3714 square miles. In 1965, 6.7 million people resided there, compared to 4.5 million in 1940. A population of 9.3 million is projected for 1990 (N. Ill. Plan. Comm., 1965, p. 12). The area is presently being urbanized at the rate of 10,000 acres or 15.6 square miles per year (N. Ill. Plan. Comm., 1965, p. 14). The greatest demand is for land for residential building. In northeastern Illinois there is not only a concentration of population and mineral production, but there is also a combination of nearly all the pressures and problems that confront mineral industries in other urban areas.

This region has been blessed with abundant resources of stone, sand, and gravel. However, years of production have been gradually depleting the resources at the earliest worked, and perhaps best, production sites. In the future new sites must be selected in locations outside the existing built-up areas, where the greatest problems of conflicting land use occur. Here mineral producers must compete with agriculture, expanding industry, real estate developers, highway builders, and park and recreation agencies for the decreasing amount of available land.

Stone Resources and Operations

Figure 8 shows the production of stone in northeastern Illinois from 1942 to 1965 by geographic region. The Chicago metropolitan area is shown in dotted and lined patterns, while the black area indicates the outer tier of counties surrounding the metropolitan region. This fringe area is included because part of the growing demand for mineral aggregates within the metropolitan region will probably be met by quarries located in this outlying area. Cook County, shown in dotted pattern, has,to date, continued to supply the bulk of stone production despite increasing demands. Although the greatest increase in production has occurred in Cook County, both other areas shown have more than doubled their tonnage of stone during the past 25 years.

Figure 9 shows the bedrock geology (Suter et al., 1959, p. 23) and the locations of major stone quarries operating in the northeastern Illinois area. These quarries accounted for more than 99 percent of the reported production in the six-county area in 1965. The major quarries, with one exception, produce from the Silurian rocks, which are predominantely dolomites.

One of the principal factors determining the location of a quarry is the thickness of the stone. For high-tonnage operations, producers generally are interested in quarrying the thickest deposits available. The stone, of course, must be of sufficient quality to meet specifications. Figure 10

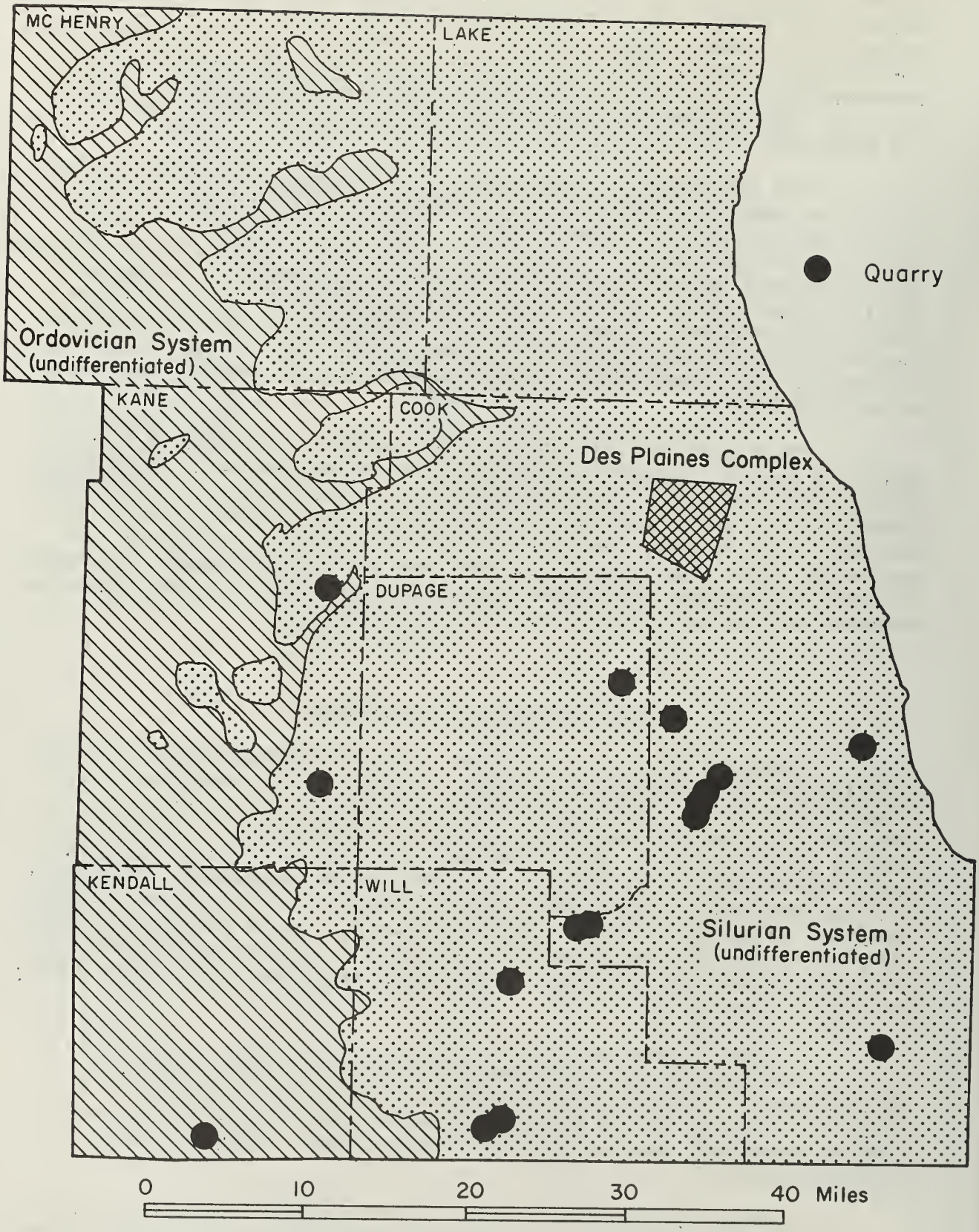


Fig. 9—Bedrock geology of northeastern Illinois (Suter et al., 1959, p. 23). Black dots indicate the locations of major quarries reported operating in 1965.

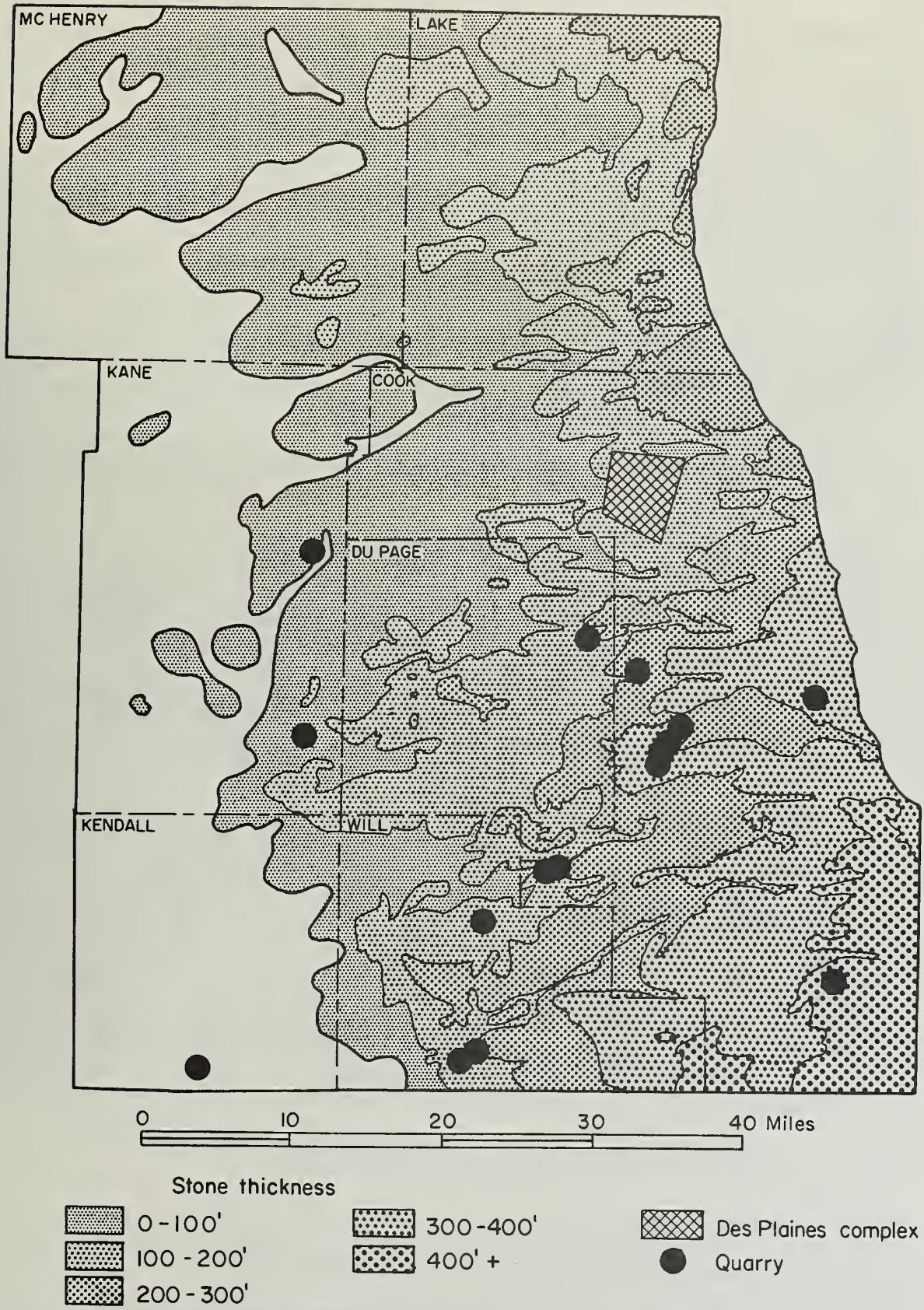


Fig. 10—Thickness of the Silurian System rocks based on 100-foot contours (Suter et al., 1959, p. 37).

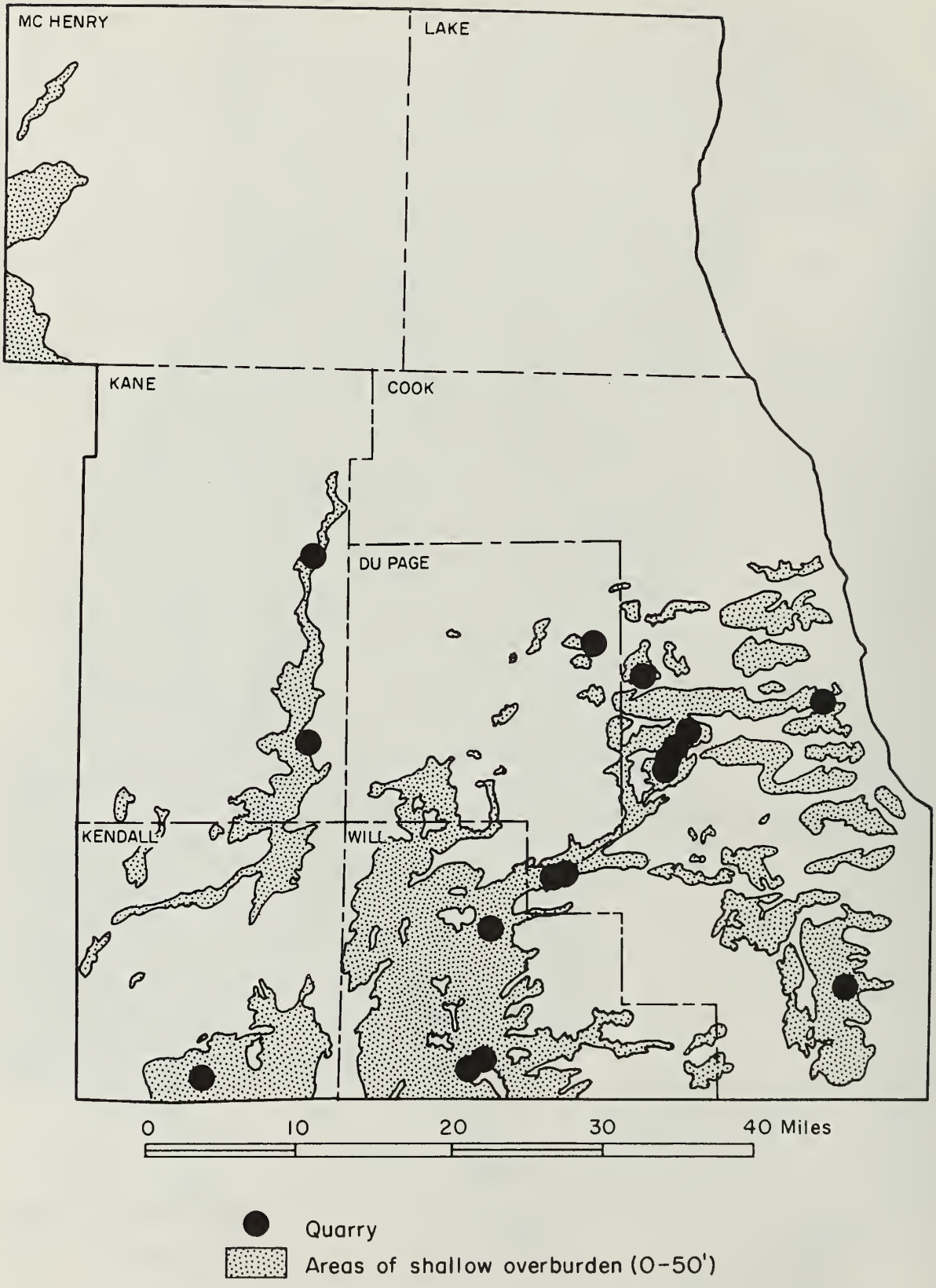


Fig. 11—Areas where the thickness of unconsolidated deposits overlying the bedrock are 50 feet or less (Suter et al., 1959, p. 18).

indicates the thickness of the Silurian System rock at 100-foot contour intervals (Suter et al., 1959, p. 37). Present quarry operations are concentrated in the thicker deposits in the southeastern quarter of the region.

In Figure 11, the areas in which the thickness of overburden is 50 feet or less are shown by the dotted pattern (Suter et al., 1959, p. 18). The presence of thick overburden helps explain the absence of operations in the northern half of the region. This map indicates beds of thick rock are present at shallow depths in southern Cook County for potential production in the future. Unfortunately, other factors tend to restrict their use.

Figure 12 shows the pattern of urbanization for the area, and the relation between pits and quarries and urban areas. The "urbanized areas" include all incorporated cities, towns, and villages, all parks, and all government installations. The map shows that much of the thick, shallow stone deposits in Cook County are no longer available for mining by open pit methods because they have been built over by the city of Chicago and its suburbs, which presents serious restrictions to future development of the quarrying industry.

As the present quarries are worked out, future production must come from new and more distant sites, or possibly from underground operations. Underground mining beneath large cities presents its own problems, too involved to deal with here. The maps indicate that moving to outlying sites generally would mean quarrying thinner stone and removing possibly thicker overburden. Stone up to 100 feet is sufficiently thick to provide good quarrying conditions. Such thickness would, nevertheless, represent quite a change from the 200- to 400-foot stone commonly quarried in northeastern Illinois and would require larger areas to produce a given amount of stone.

It appears likely that the greatest possibilities in the long term future expansion of the stone industry of the Chicago area will be to the south and west into northern Will County. Such a shift will greatly increase the hauling distance to metropolitan consuming centers. For example, should the stone that presently comes from within Cook County become unavailable because the present quarries were closed and stone from Will County used to replace it, the hauling distance would be more than doubled. At 5 cents per ton-mile, this would add at least $1.00 per ton to the delivered cost of aggregate in the inner city. Average hauling distances and costs will be lessened to some degree as urbanization and construction activities move toward the outlying quarries.

Sand Resources and Operations

Figure 13 shows sand production in the northeastern Illinois area. The three regions indicated by stipled and lined patterns are within the Chicago metropolitan area; the outer tier of counties surrounding the metropolitan area is indicated in black. All of the regions have increased production from 1940 through 1965. However, since the early 1950's the greatest growth in production has occurred in McHenry and Kane Counties, reflecting

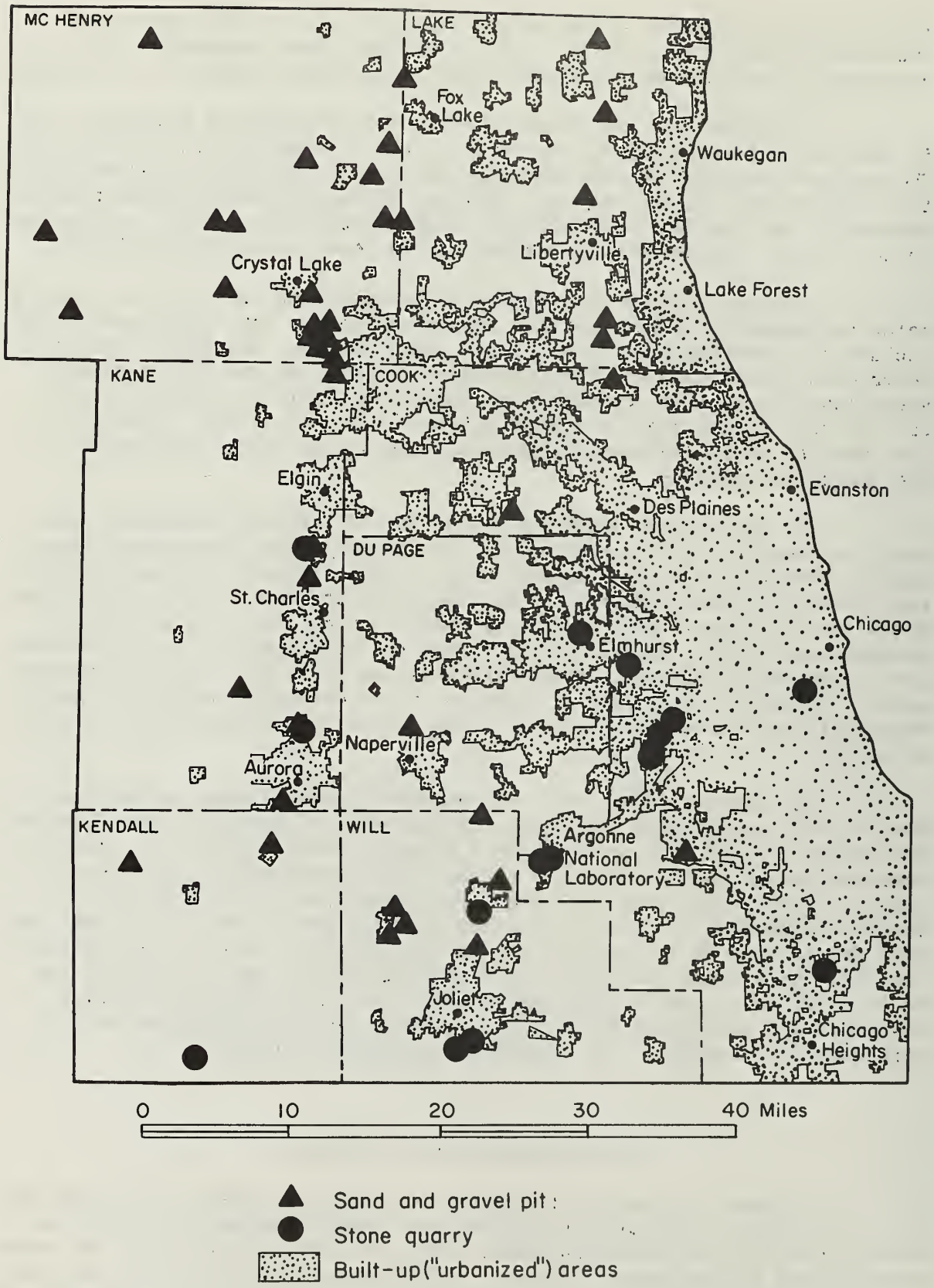
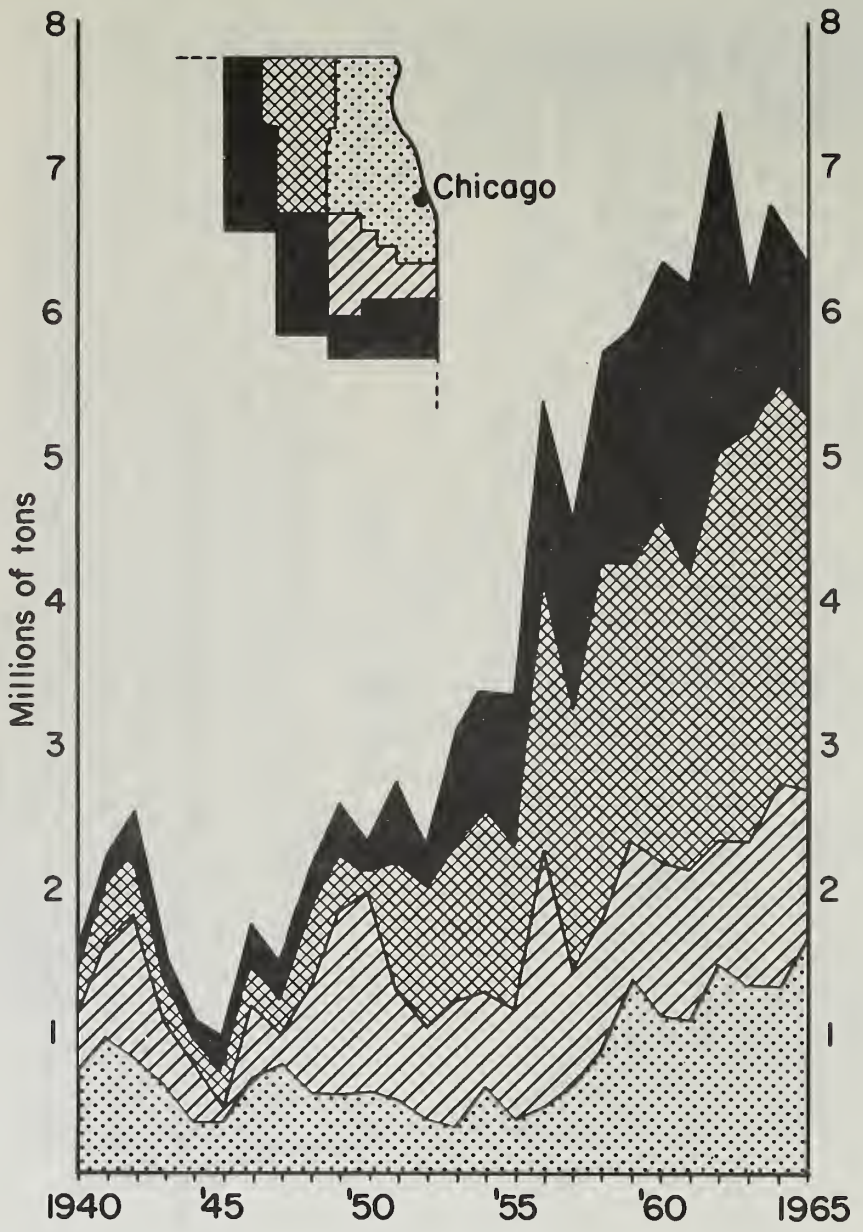


Fig. 12—Urbanized areas in relation to sand and gravel pits and stone quarries in northeastern Illinois.



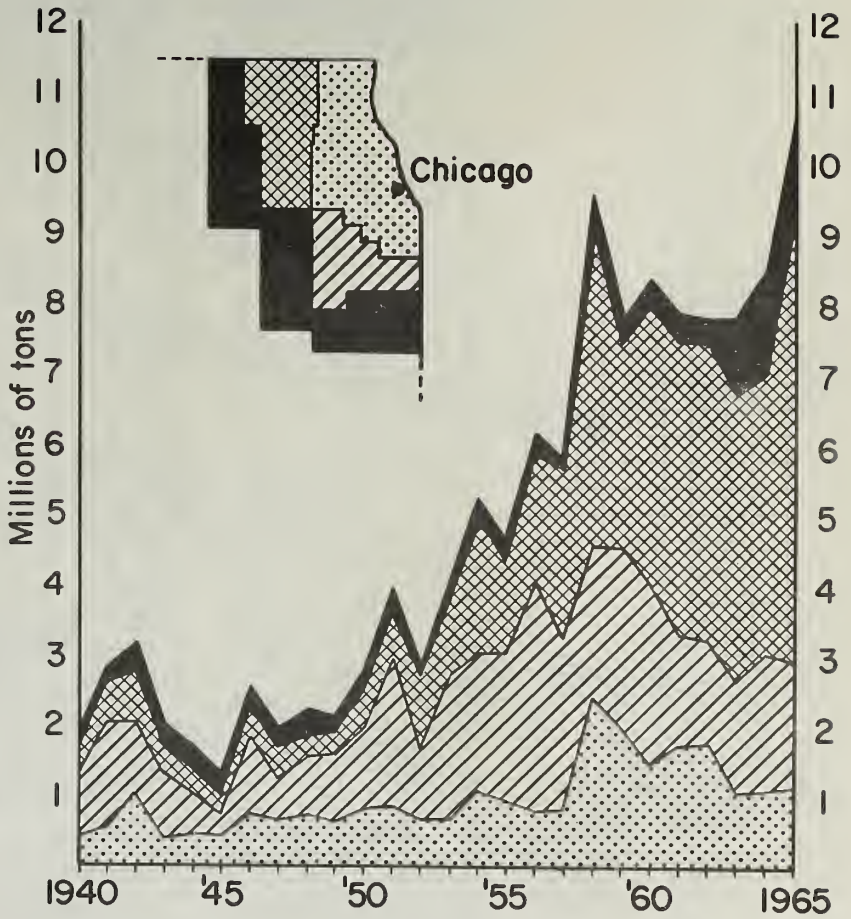


Fig. 13—(left) Sand production in northeastern Illinois, 1940-1965.

Fig. 14—(above) Gravel production in northeastern Illinois, 1940-1965.

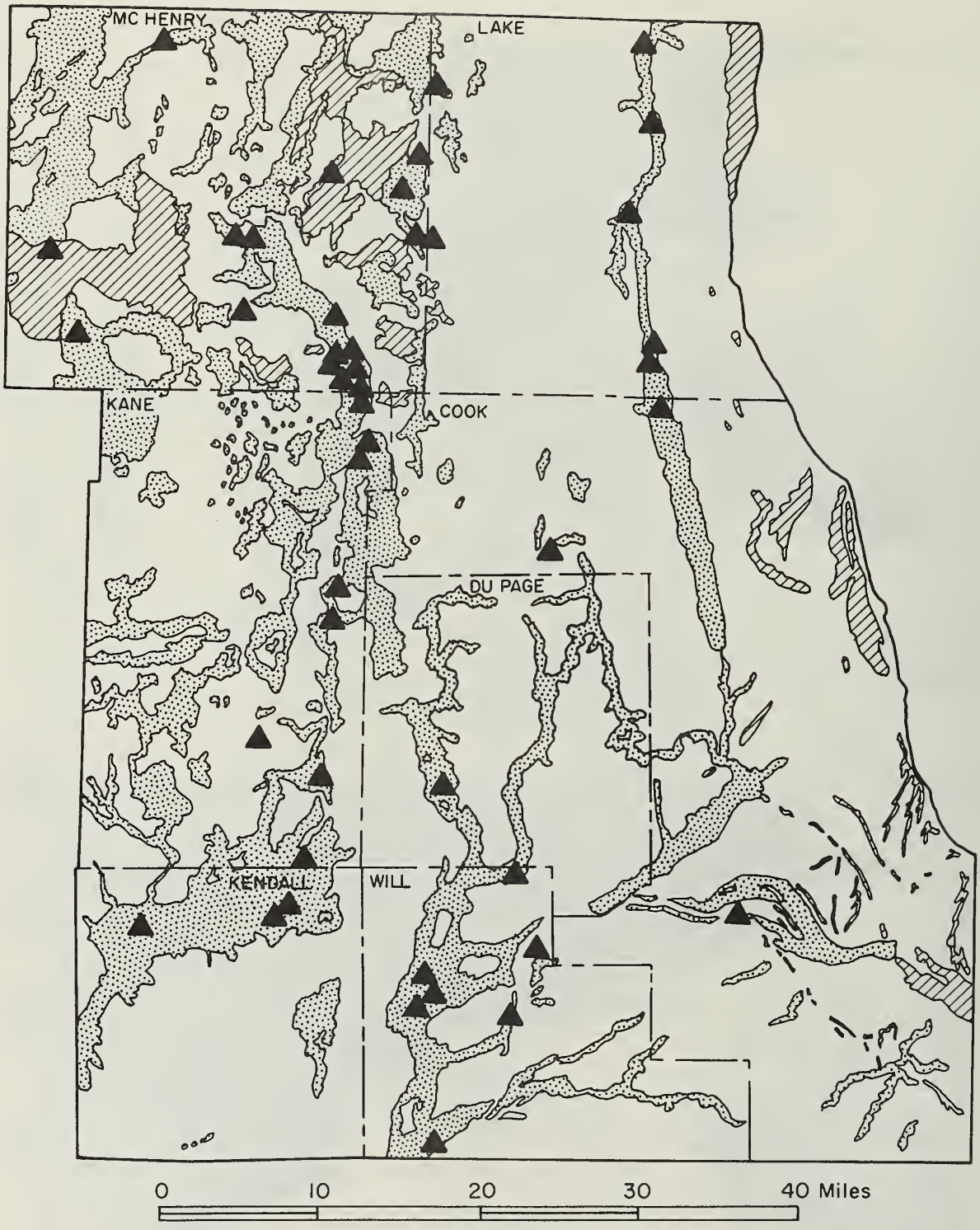


Fig. 15—Sand and gravel resources and operations in northeastern Illinois. Resource data adapted from Ekblaw and Lamar (Ekblaw and Lamar, 1964).

the outward movement of the market resulting from suburban growth or urban sprawl and also, to some extent, the inability of the inner city area (shown in dots) to meet all of the increased demand. A rapid rise in sand production in the outer tier, especially in Grundy County, started in 1957. This is due partly to the outward displacement of sand pit operations and partly to the low-cost water transportation along the Illinois Waterway.

Gravel Resources and Operations

Figure 14 shows similar data for gravel production in the northeastern Illinois region from 1940 through 1965. Kane and McHenry Counties again show the greatest growth in production. However, in contrast to the trend for sand, the production of gravel in Cook, Lake, DuPage, and Will Counties has declined since 1958. The outer tier counties have shown rather meager growth. The sizable increase in production in McHenry and Kane Counties can be explained to a large extent by the geographic distribution of sand and gravel resources in the northeastern Illinois region.

Figure 15 shows the sand and gravel resources and the locations of pits from which production was reported in 1965. The dotted pattern indicates mixed sand and gravel deposits commonly occurring at depths of 10 feet or less, including outwash plain, valley train, kame, esker, and stream alluvium deposits. The lined areas represent deposits composed mostly of sand. The most extensive sand and gravel deposits are located in the western third of the area, especially in Kane and McHenry Counties. Smaller deposits occur along the DuPage, DesPlaines, and Illinois Rivers. Because of the large market in the eastern half of the region, greater use of these deposits might be expected. The reason for the relative lack of operations along these rivers is indicated on figure 12, which shows that the majority of the potential sand and gravel reserves in the inner counties—Cook, Lake, and DuPage—are already covered by, or are presently being threatened by, urbanization. There appears to be a conflict in land use even in outlying Kane County, where most of the present pits are located along the Fox River. That river valley is also rather heavily built up with towns such as Elgin, St. Charles, Geneva, and Aurora. As these towns are predominantly residential in nature, the pits are likely to come under increasingly stringent zoning and operational restrictions.

ZONING RESTRICTIONS

At the present time, one of the most serious challenges to the mineral producers in urban areas is the growing amount of regulation by local government through zoning ordinances. The courts have upheld the right of zoning boards to prohibit the opening of a new quarry or pit and to close down an existing mineral operation if it is ruled to be a nuisance. ROCK PRODUCTS magazine recently polled hundreds of producers across the U. S. and revealed actual cases of pits and quarries having been closed down by community action and of plants forced to relocate because of local pressures (Stearn, 1966, p. 77-78). In addition to the usual zoning

regulations, many communities have passed ordinances that place restrictions of an operational nature on producers. These ordinances relate to the permitted hours of operation, dust control, noise level, blasting vibrations, screening, use of minor residential streets for haulage, and many more features of operations.

FUTURE PLANNING

Advance planning for multiple or sequential land use, with land rehabilitation and optimum final land use in mind, can be of great assistance in helping stone, sand, and gravel producers to retain their present operating rights or to gain new rights in the face of threats from more stringent zoning ordinances. The industry is becoming increasingly aware of the need to educate the public about the proper and useful role of the industrial minerals producer, not only in the community's economy, but also in the wise sequential use of land in the community. Some excellent public relations and educational programs of this type are already being carried out by trade associations and individual companies.

Projections indicate that a cumulative production of 13.5 billion tons of sand and gravel and 11.4 billion tons of stone will be required to meet the market demands in the U. S. within the next decade. This is the great challenge. But to benefit from this huge demand, producers must be willing and able to face up to the associated problems.

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